B52A-0744 1330h POSTER

Respiration and Dissolved Organic Carbon Dynamics in an Area Undergoing Permafrost Degradation

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Permafrost degradation in Tanana Flats, Fairbanks, AK has resulted in the conversion of paper birch (Betula papyrifera) and black spruce (Picea mariana) forests to fens and bogs. Increased organic matter accumulation in the wetlands has been documented, but effects of the shift from forests to wetlands on carbon cycle processes have been largely unexplored. Soils were collected from 10-25 cm from four different landscape types within Tanana Flats to investigate respiration rates and dissolved organic carbon (DOC) quantity and quality. The sites included a bog (B-Bog) and a fen (B-Fen) that were formerly birch forest, a black spruce forest with permafrost (S-Forest), and a bog (S-Bog) within the black spruce forest. Soils were incubated at field moisture for 11 weeks at 5°C and 17°C. Respiration was measured five times during the incubation period. Twenty-four hours after each respiration measurement, soils were saturated with water (50 ml) and allowed to drain for one hour. The water was filtered and analyzed for DOC concentration and ultraviolet (UV) absorbance at 254 nm. Respiration generally decreased with time for all soils, and the relative rates of respiration (normalized for grams soil) followed the pattern: S-Bog<B-Bog<S-Forest<B-Fen, at both temperatures. Respiration rates were approximately two times greater at 17°C than 5°C for all soils. Soil leachate DOC concentrations generally decreased with time, and specific UV absorbance (SUVA: absorbance/DOC concentration) generally increased with time for all soils. DOC concentrations were not significantly different at the two temperatures. DOC concentrations (normalized for grams soil) generally followed the pattern: B-Fen<S-Bog<B-Bog<S-Forest at both temperatures. SUVA, an indicator of DOC aromatic carbon content, exhibited the opposite trend. Strong positive linear relationships between respiration and DOC concentration were exhibited for all soils at 17°C (R^2=0.61 to 0.99), but only for B-Fen at 5°C. The slopes were nearly identical for B-Fen and B-Bog (0.69, 0.66) and similar for S-Forest and S-Bog (0.22, 0.34). Respiration from the bog and fen soils at 17°C was negatively correlated with DOC SUVA (R^2=0.72 to 0.92), and again the slopes for B-Fen and B-bog were identical (-287). These results indicate that DOC is an important source for microbial activity in the black spruce forest and the collapse wetlands, and that the relationship between soil respiration and DOC is retained to some extent when a forest becomes a wetland due to permafrost melting.

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Carbon and Nitrogen Cycling in Land-use Systems Experiencing Extremes in Moisture Inputs

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Changes in the C and N cycling are pronounced when an invasive legume species such as mesquite (Prosopis spp.) inputs N into a previously N limited grassland or riparian area. This work documents vegetation inputs and soil C and N inventories from different vegetation communities in a semi-arid environment in southeastern Arizona. The C and N balance of the mesquite C and N litter input into sacaton (Sporobolus spp.) grasslands includes analyzing the different plant tissues for C and N content and isotope signatures, and documentation of the carbohydrates, amino acids, phenolic acids, lipid and lignin composition and content. The litter horizon and the soil to a depth of 60 cm under the different vegetation were also analyzed in a similar manner. Mesquite invasion into grasslands resulted in input of mesquite N that impacted soil C content, C isotope values and carbohydrate and amino acid content compared with noninvaded grasslands. The yearly pulse of mesquite N to the grassland increased grass productivity per bunch from 148 g (n = 3) in an isolated noninvaded grassland to 550 g (n = 3) in grasses in the understory of mesquite community. Cool season litter (2.9% N) collection (October 2001 to March 2002) recovered of 66 g mesquite C and 4.5 g mesquite N m^{-2}. The litter input was correlated with tree size (r = 0.94) and when compared with the litter remaining in the understory, approximately 3 to 8 years of plant litter remained on the soil surface. Soil cores were removed from within the riparian mesquite community, returned to the lab and incubated at constant moisture potentials, determined CO2-C was linearly respired for up to 80 d. The disconnect between litter fall and moisture conditions present in the ecosystem allows the build-up of high quality plant litter in the ecosystem understory. Measurement of the surface litter amounts present in the different riparian plant communities found under mesquite-grass vegetation about 750 g litter m^{-2}, under mesquite about 598 g litter m^{-2} and in an open area dominated by annuals and forbs about 160 g litter m^{-2}. Increased net plant productivity in mesquite-populated sites compared to grasslands can result in higher soil C and N contents in the litter and surface soil.

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Assessing Methyl Bromide Flux in a Freshwater Peatland

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Freshwater peatlands are a source of atmospheric methyl bromide (CH_3Br), the most abundant bromine containing gas in the troposphere and a significant ozone depleting substance in the stratosphere. Previous measurements made by our laboratory indicate that peatlands release approximately 4.6 Gg of CH_3Br per year. Factors that control the variability and magnitude of this net flux are not fully known, however. Measurements of CH_3Br surface-atmosphere exchange in a New Hampshire peatland using static enclosures indicate a correlation between CH_3Br emission and water level and temperature . Net fluxes for 1998-2000 ranged from -42 nmol/m^2/day to 40 nmol/m^2/day (negative values indicate CH_3Br consumption). Concentration profiles within these chambers over the sampling time show an initial increase in CH_3Br followed by a decrease. This suggests that static enclosures may alter surface-exchange conditions and result in underestimates of net flux in these ecosystems. We describe the development of a clear dynamic chamber sampling system to more accurately determine net CH_3Br flux. Net fluxes measured with these enclosures range from -10 nmol/m^2/day to 46 nmol/m^2/day. This system is currently being applied in a vegetation study to determine the effect of plants on peatland CH_3Br exchange.

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Investigating Soil Carbon Dynamics Using N-15

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The carbon and nitrogen cycles in soil are intimately linked. Past research has often focused on using carbon-to-nitrogen ratios as directors of them ineralization-immobilization reaction of both elements. This close relationship is useful for researchers studying the carbon cycle, because detectable changes in the size of stored carbon pools are often slow to occur and difficult to detect. Nitrogen, in contrast, cycles quickly in soils and has at least three easily monitored pools, total nitrogen,ammonium-nitrogen, and nitrate-nitrogen. The N-15 pool dilution technique,entails the application of small quantities of highly enriched mineral sources of N-15 (from potassium nitrate or ammonium sulphate) to known volumes of soil and 24 h later the dilution of the applied N-15 with the more prevalent N-14 is measured. This procedure was conducted in three plots of a tallgrass prairie restoration chronosequence (farmland restored to tallgrass prairie in 1979, farmland restored to prairie in 1993, and farmland still in production with row crops) and in two loblolly pine plantation research plots (fertilized and never fertilized). At the prairie site, the farmed soil had significantly higher rates of all transformations(mineralization, ammonium consumption, nitrification, nitrate consumption)than did the restored prairies. We were able to use these nitrogen transformation rates to calculate estimates of C dynamics in these soils. For example, we estimate that the microbial biomass turnover rate in the non-fertilized loblolly pine soil was 44 d, but in the fertilized plot it was 9 d. We also interrogate these rates with other data collected on the soils to estimate the amount of C that could potentially be lost from or stored in these soils under the conditions investigated

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Oxygen Effects on Carbon Trace Gas Production in Wet, Tropical Forest Soils

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The flux and carbon isotope composition of CH_4 emitted from wet tropical forests are strongly affected by fluctuations in redox conditions. Quantifying these effects is crucial for evaluating the role that tropical environments play in the global CH_4 budget. This study explores the effects of soil O_2 variations on the balance between methanogenesis, methane oxidation and the $\delta^{13}C$ value of the CH_4 emitted to the atmosphere across natural gradients of soil O_2 in the Luquillo Experimental Forest in Puerto Rico. Sources and sinks of CH_4 in both the soil profile and across the landscape were identified through the analyses of soil gas concentrations, flux rates and stable isotope distributions. Above atmospheric concentrations of CH_4 were measured at depths of >40 cm in all plots, while near-atmospheric or below atmospheric levels of CH_4 were observed in the 0-15 cm depth. Increases in soil CH_4 with depth was associated with a decline in both soil O_2 concentrations and in the $\delta^{13}C$ values of CH_4. Decreases in soil CH_4 in the 0-15 cm depth was coincident with increases in O_2 concentrations and ^{13}C enrichment in the $\delta^{13}C$ value of soil CH_4. These trends suggest that methanogenesis outpaces methane oxidation deeper in the soil, while CH_4 oxidation increases near the soil surface. At the whole-ecosystem scale, the lower O_2 plots were net sources of CH_4 to the atmosphere, and the more aerobic plots were either very weak sources, sinks or at net balance. Isotope mass balance calculations suggest that more than 86% of the methane produced at depth was oxidized in surface soil horizons. Follow-up studies in the laboratory were conducted with intact soils exposed to a range of O_2 partial pressures, to explore the effect of oxygen variations on rates of gross methanogenesis. Difluoromethane was applied to inhibit methane oxidation. Incubations of soils collected from the same plots had similar rates of methanogenesis, regardless of oxygen partial pressures. Rates of methanogenesis were similar for soils collected from both the 0-15 cm and 40-60 cm horizons within the same plot. This suggests that net CH_4 flux is probably regulated by changes in rates of CH_4 oxidation rather than by fluctuations in rates of methanogenesis.

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CO_2 Exchange and CH_4 Flux in a California Rice Paddy

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We present results from a study aimed at quantifying CH_4 and CO_2 exchange from a California rice paddy. CO_2 exchange was measured using the eddy covariance technique over a two year period. Vertical profiles of CH_4 and CO_2 have been measured on an hourly basis, semi-continuously since November 2001. By combining these measurements, we have calculated CH_4 fluxes at crucial stages of the growing and post-harvest season using the flux gradient approach. We compare the CH_4 fluxes obtained by the micrometeorological techniques to weekly chamber measurements. We discuss the implications of nighttime inversions on the vertical gradients of CH_4 and CO_2 and the turbulent exchange of these gases. Finally, we compare the ratio of CO_2 exchange to CH_4 flux at short (daily), medium (2-4 weekly) and annual timescales to quantify the role of CH_4 in the carbon cycling of rice paddies.